Space Weather Technical Forecast

Issued on Monday, 10 June 2024 at 00:18 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Risk of Minor/Moderate (G1/G2) day 1 (10 June). Chance of M-class flares (R1-R2; Minor-Moderate radio blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity has been Moderate at GOES16/18 during the past 24 hours, with occasional weak M-class flares, peaking with an M1.6 from AR3697 at 09/0701UTC.
There are currently ten active regions on the visible disc. The most active region on the disc is AR3697 (Dkc/Beta-Gamma-Delta) on the southwest limb, and is increasingly difficult to analyse, but appears to have reduced a little in size. Other regions are smaller, magnetically simpler and either showing slight decay or little change in development. No new significant Earth-bound CMEs were observed in the period.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE at L1, showed coronal hole high speed stream (HSS) influence for much of the 24-hour period. Solar winds were elevated at first with a peak speed of 538 km/s at 09/0101 UTC, before easing back towards Slow-ambient levels by the end of the period. The density remained below average. The IMF (Interplanetary Magnetic Field) was at weak levels peaking at 6nT. The north-south component varying between -5nT and +4nT. The phi angle fluctuated between positive (away from the Sun) and negative (towards the Sun). The net result of the above solar wind measures was for Quiet (Kp 1 to 2) geomagnetic conditions.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 continued to ease from Minor (S1) radiation levels to just below late in the period. 100MeV protons also showing a slow downward trend.

High energy electron flux (greater than 2MeV) observed by GOES16 was at predominantly Normal Background levels, with the associated 24-hour fluence well below Active. Observed fluence at 09/2100 UTC was 1.24e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a Chance of further isolated M-class flares, most probably from AR3697 or AR3709. The probabilities of the former reducing in the next couple of days as it rotates away from the visible disc.

Solar Wind / Geomagnetic Activity: The CME associated with the 08/0149 UTC M9.7 flare showed an asymmetric halo in its shock, and there is a risk of G1/G2 Minor/Moderate geomagnetic storm conditions on day 1 (10 June). This is the only CME currently in the forecast. Solar winds are likely to be at slow-ambient levels day 1 (10 June) but may become elevated, perhaps strong (around 600km/s), with the CME arrival. Winds will then probably subside through days 2 and 3 (11 and 12 June).

Geomagnetic activity starting at Quiet levels before the arrival of the 08 June CME during the

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

UTC morning of day 1 (10 June). This could bring G1/G2, Minor/Moderate geomagnetic storm conditions for a time. Elevated geomagnetic activity may linger into the start of day 2 (11 June), before gradually waning to Quiet again for days 3 and 4 (12 and 13 June).

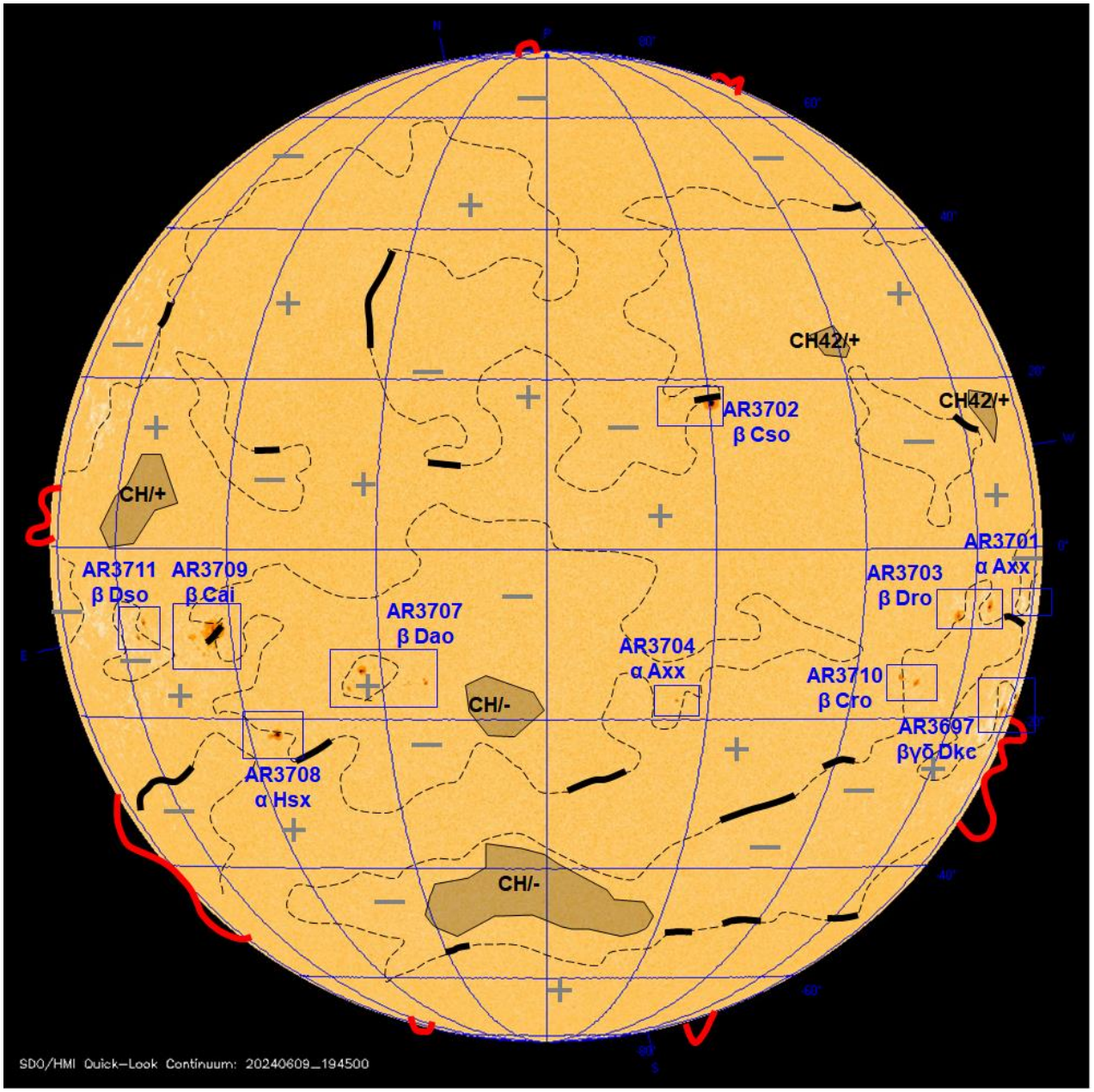
Energetic Particles / Solar Radiation: High energy proton flux will probably continue waning, and is now at background levels. The risk of further storms continuing due to the proximity of AR3697 on the southwest limb.

High energy electron flux is forecast to persist at predominantly Normal Background levels, and the associated 24-hour fluence forecast should remain below the Active threshold. There is a Chance of recovery through the period in the wake of the recent HSS, however any CME influence could temporarily suppress levels again.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 1. Solar Analysis Valid 2000UTC, 09 June 2024.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Met Office Space Weather Technical Forecast

Geomagnetic Storms:

The M9.7 flare from AR3697 at 08/0149UTC in the southwestern disc generated a Coronal Mass Ejection (CME). A substantial coronal dimming and EUV wave were also observed, with the latter crossing the solar meridian in the minutes following the flare. Also observed were a 10cm radio burst, Type II and Type IV radio signatures, with the former of these giving an estimated CME speed of 894km/s. The ejecta show a (possibly double-lobed) asymmetric halo on coronagraphs. MOSWOC Enlil modelling suggests a likely arrival time at Earth in the UTC morning of day 1 (10 June). Most of the ejecta appears directed south and west of the Sun-Earth line, but there may be up to two shocks that appear to impinge on the Sun-Earth line, and a glancing blow of some description is therefore expected. No other new CMEs were noted in the period.

Solar winds have been predominantly slightly elevated, with levels starting at elevated levels, and peak solar winds at around 540 km/s. This enhancement is likely from the elongated and rather narrow CH42/+ in the northwest disc, which is waning as solar winds decline to slow-ambient levels. On day 1 (10 June) solar winds could potentially become elevated, perhaps strong (around 600km/s), with the anticipated CME arrival. Winds will then gradually subside.

Geomagnetic activity is expected to be Quiet on day 1 (10 June). The arrival of 08 June CME is expected during the UTC morning of day 1 (10 June), with a risk of G1/G2, Minor/Moderate geomagnetic storm conditions for a time. Elevated geomagnetic activity may linger into the start of day 2 (11 June), before waning to Quiet through the remaining couple of days of the guidance period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	50	20	1	1
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

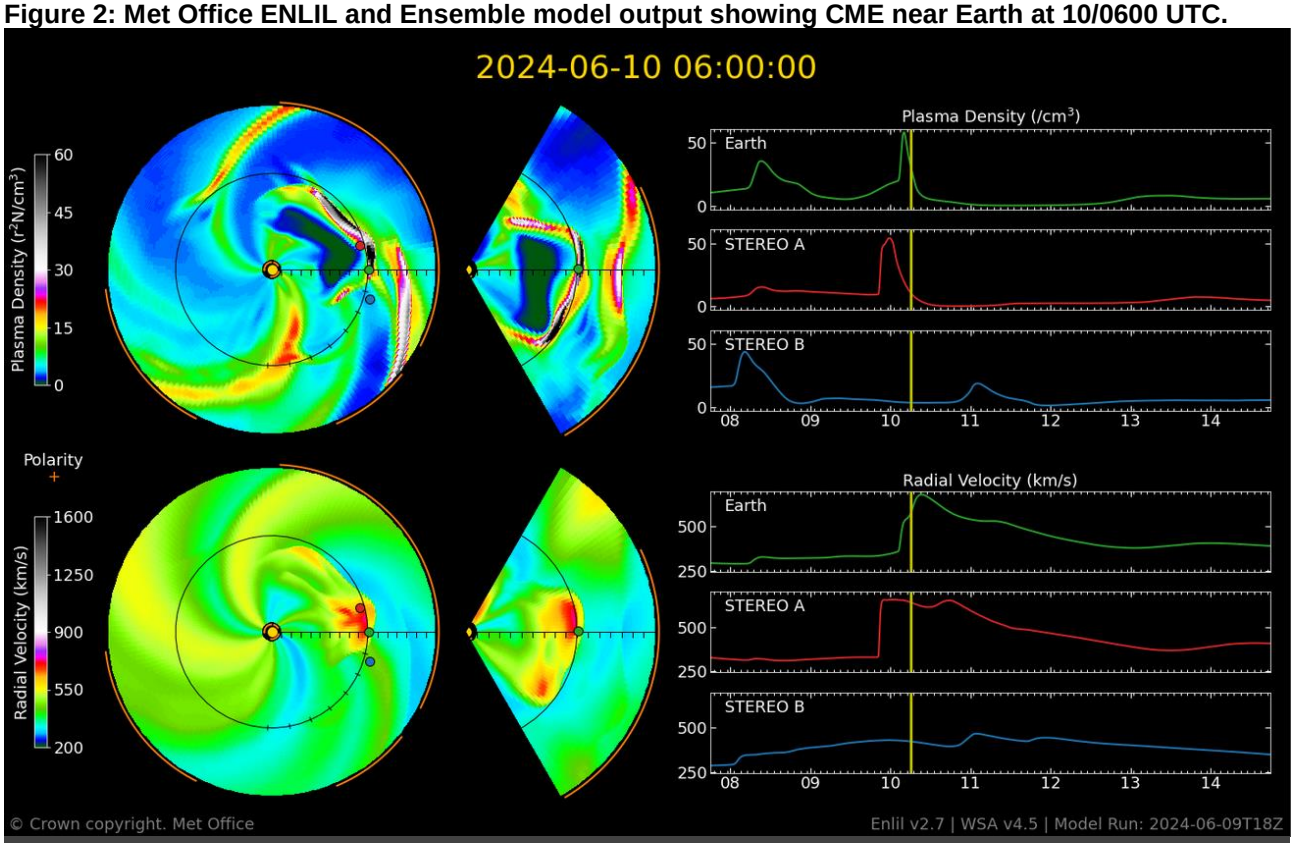
Geomagnetic Activity - Earthbound Coronal Mass Ejections

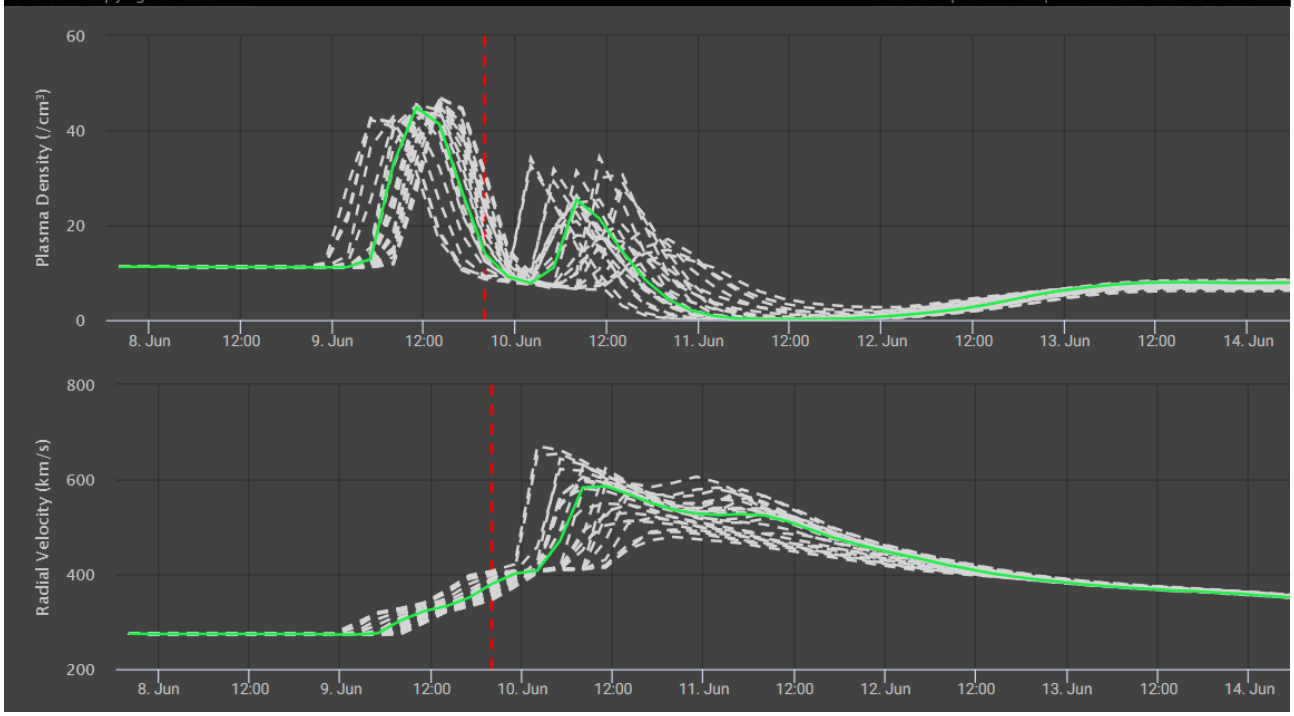
Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
08/0439	Partial	AR3697	SW	1154 km/s	10/0600 UTC	Mainly shock, but large event. Arrival error bars probably contained wholly within UTC morning of 10 June

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 2: Met Office ENLIL and Ensemble model output showing CME near Earth at 10/0600 UTC.





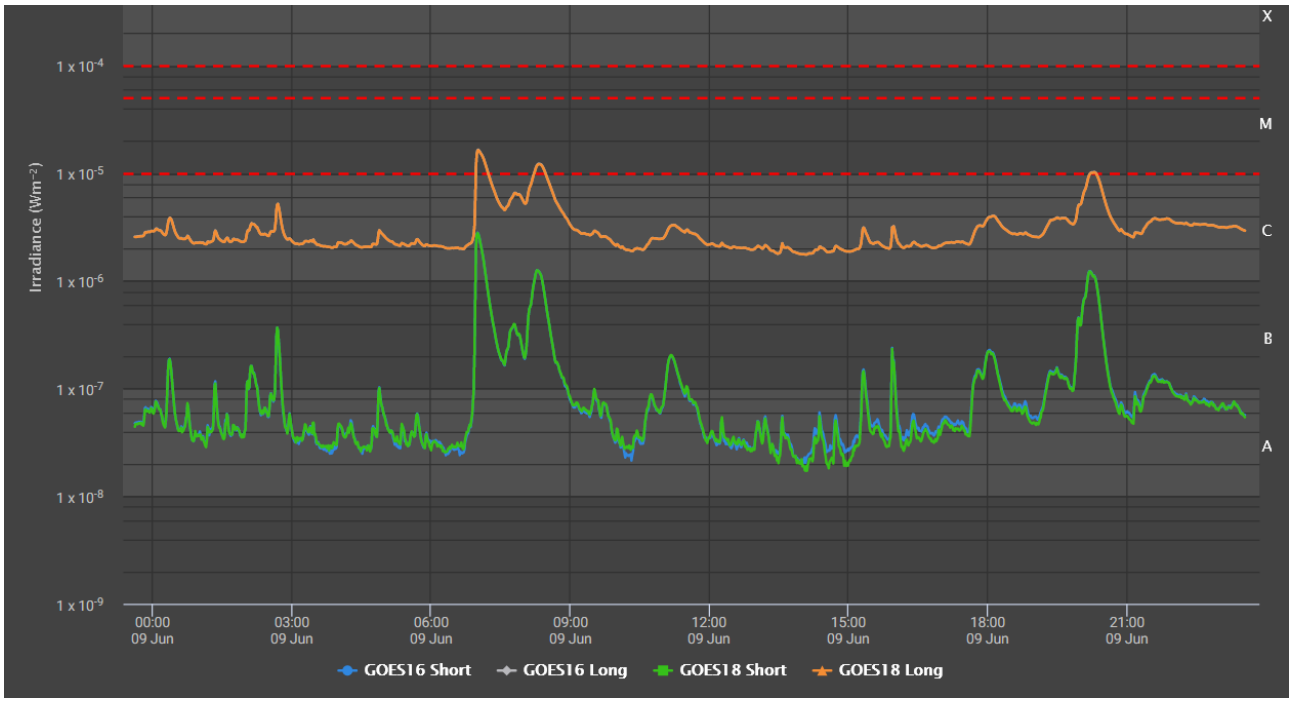
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Radio Blackouts - X-Ray Flares:
Solar activity has been Moderate during the last 24 hours, with a couple of weak M-class flares from the soon to be largest active region of the visible disc, AR3709, located in the southeast, and AR3697 on the southwest limb and about to rotate away in the next few hours.
There is a reduced chance of further isolated M-class flares along with a slight chance of an X-class flare. These most probable from AR3697 or AR3709. AR3697 departs the Earth-facing disc during 1 (Monday 11 June), leading to a further reduction in daily risks, with far-side soundings not suggesting any substantial arrivals from the far-side in this current guidance period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	40	20	30
Very Active	R3 to R5 X Class	No	10	5	1	1

Figure 3: X-ray flux plot at GEO showing minor M-class flares in past 24 hours.



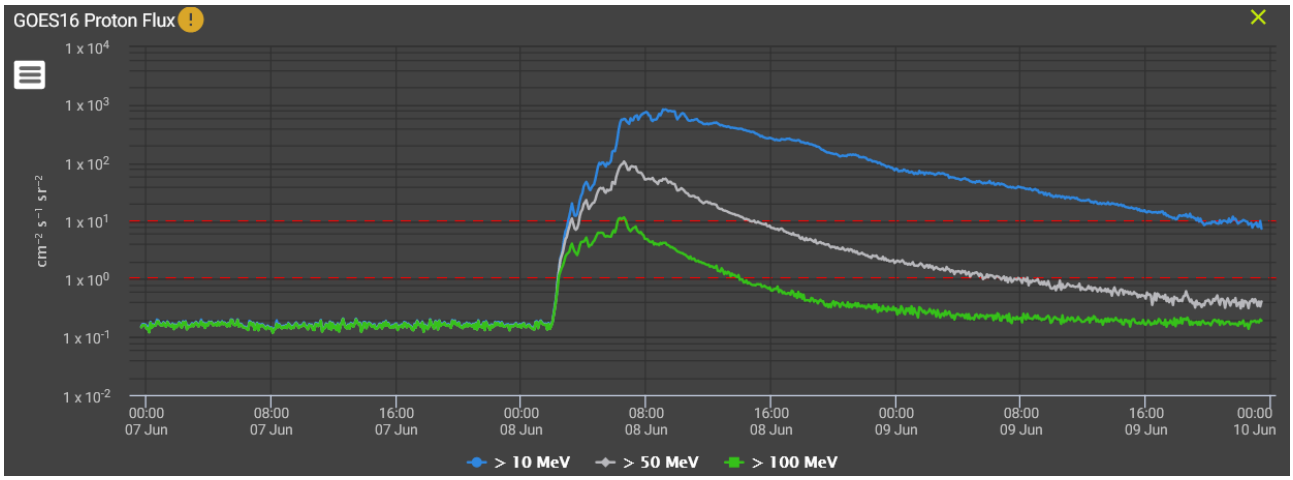
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):
AR3697 is currently in a prime position to deliver further S-scale enhancements should it flare suitably. Given the enhanced levels of greater than 10MeV protons in the interplanetary medium, this means further exceedance of S1 is rated as a 50% Chance, with this risk falling in coming days.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	50	20	10	5
Very Active	**≥ S3 ***	No	5	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES 16 proton flux at GEO with recent solar storm near S3, now waning steadily.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):
The high energy electron flux is likely to persist at Normal Background levels for much of this period - now rendered more likely by the anticipated inbound 08 June CME.

MOSWOC REFM output is viewed as limited for good guidance, although it maintains fluence below the Active level. However, it cannot account for the incoming CME and its range is not sufficient to hint at any potential rise in the T+72-96 hour period.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	5	10	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: High energy electron flux at GEO and Met Office REFM output, with recent data outages.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.